# Diagnosis Network Performance For Conducted EMI Measurement

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## I. INTRODUCTION

Current the most common test instrument for conducted electromagnetic interference (EMI ) measurement is an EMI test receiver with a line impedance stabilization network (LISN). LISN is a network specified in the standard for interfacing the power utility and the equipment under test (EUT). It can only measure total conducted EMI on the power lines but it cannot detect the common-mode (CM) and differential-mode (DM) components of the conducted EMI separately. Since CM and DM signals are essential data for designing power line filter for EMI suppression, conventional LISN will not be able to provide the users any additional useful information if the products fail to meet the required EMC limits.

The principle of common-mode and differential-mode discrimination network (CM/DM DN) or diagnosis network is based on the implementation of the adding and subtracting functions of the live and neutral noise voltages, which comes from live and neutral terminals of the LISN. The output signal of the discrimination network is either CM or DM signal of EMI emission.

Paul and Hardin presented a CM/DM discriminating network that uses a pair of identical 1:1transformers to add or subtract two voltages. The add/subtract function is achieved by reversal of one of the transformer secondary windings through a mechanical switch[1]. We presented another network employs two 2:1 transformer with center-tapped secondary to realize the function, without use of switch[2]. Mardiguian proposed a much simpler version of network that uses only a 2:1 center-tapped transformer. Guo presented another style that uses two combiners instead of transformers t oachieve similar function.

In order to have a compete knowledge of the discrimination capability for these netw orks, they are constructed and their CM/DM insertion losses and mode rejection abilities are measured.

## II. EXPERIMENTAL SETUP

To test CM/DM, the input signal should be either common-mode or differential mode (CM/DM) in nature. CM is referred to as two input signals with equal amplitude and in phase, whereas DM is referred to as two input signals with equal amplitude and out of phase. Therefore, a $0^o$ splitter and a $180^o$ splitter are used separately to generate the required signal, respectively. The HP 8753C Network Analyzer in cooperation with HP 85047AS-Parameter Test Set are used for the insertion loss and mode-rejection measurement. Fig.1 shows test setup fpr the measurement.

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## III. EXPERIMENTAL SETUP

The measured insertion losses and mode-rejection performances for the four discrimination networks are summarized as follows.

**Mode-Signal Rejection**

For DM rejection test, DM signal is supplied to the input of network and the signal at CM output terminal is measured. Ideally this mode rejection should be infinite, however, measurement often shows nonideal results because of noise. Fig.2 shows DM rejection abilities at the CM output for four networks. Guo's network has best DM rejection performance with around 40 dB at 30MHz. The other three networks have lower DM rejection performance. It can be seen that there is about 20~30 dB difference between Guo's network and other three networks. The CM rejection test is similar to that of DM rejection, but the difference between Guo's and other networks is smaller than that of DM rejection

**Mode-Signal Insertion Loss**

The DM signal is connected to the input of the network and the signal at the DM terminal output is measured.Fig.3 presents the DM insertion loss through network. It is found that all the networks exhibit low DM insertion loss. Both Guo's and Madiguian's networks show the best performance with lowest CM insertion loss.

Based on the measured results, among the four CM/DM DNs, the Guo's network that uses the combiners, has the best performance . However ,it is also the most expensive to construct. For low-cost transformed-based CM/DM DNs, the Mardiguian's network exhibits the best performance.

## IV A PRACTICAL EXAMPLE

As an example, the conducted noise of a switched mode power supply is measured for total noise, common-mode noise and differential-mode noise with and without line filter using CM/DM DN of Guo's as seen in Fig. 4 and Fig.5. It's known that usually CM noise of SMPS is dominant at higher frequency, while DM noise is dominant at lower frequency. In Fig.4(b), we find the DM output almost remain the original DM characteristic in total noise and only has about 2-3 dBuV attenuation compared total noise, whereas at higher frequency, it has about 10-15 dBuV attenuation for CM signal component, which complies with the DM insertion loss and CM rejection performance of Guo's network obtained in last section. Similarly, in Fig.7(c) it's seen that the CM signal property is kept well while the DM signal is rejected. Therefore, it is clear that this network is efficient in practical measurement.

## REFERENCES


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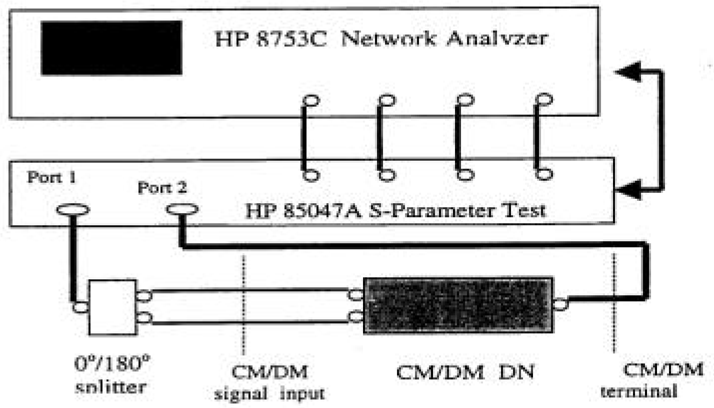



**Fig.1 Test setup for insertion loss and mode-rejection measurements**

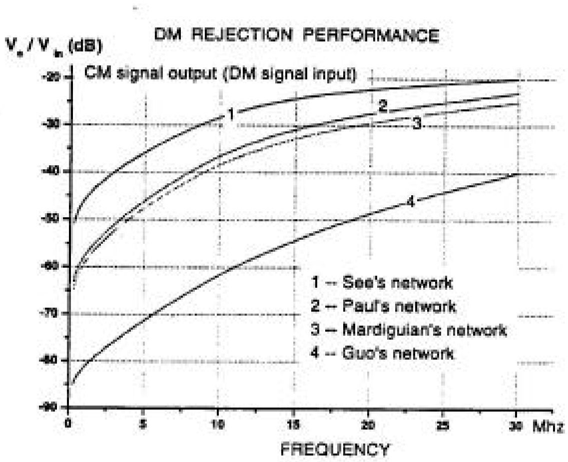



**Fig.2 DM (differential-mode) rejection performance**

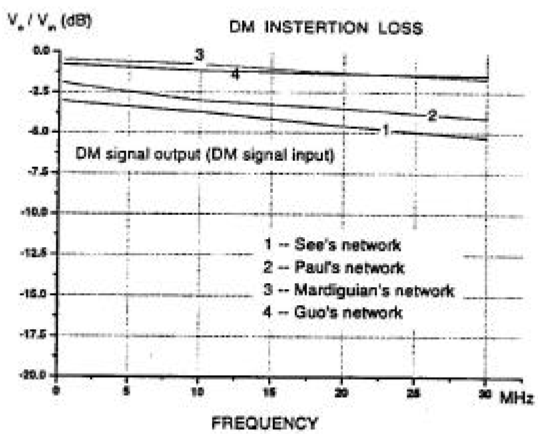
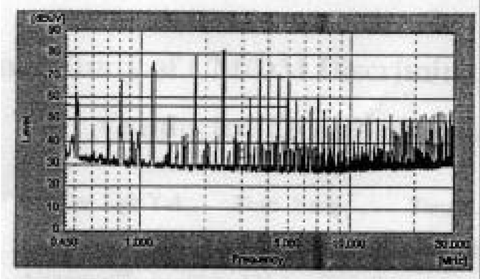
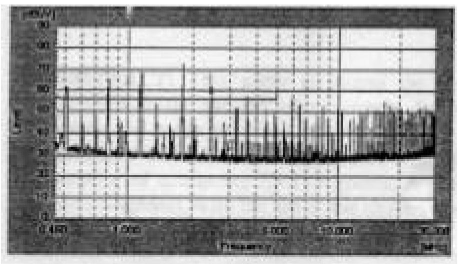


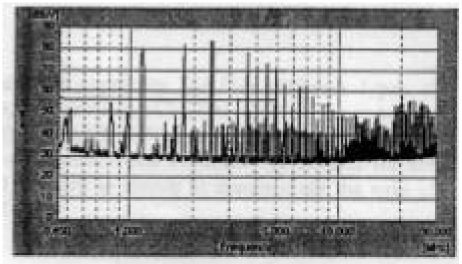

**Fig.3 DM (differential-mode) insertion loss performance**



(a) Total conduction noise

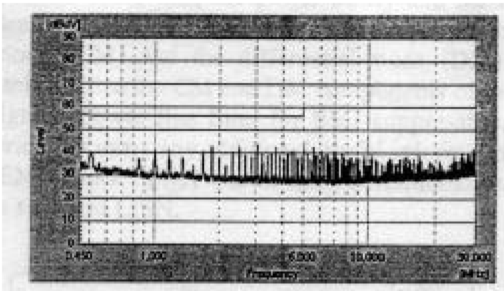


(b) DM conduction noise

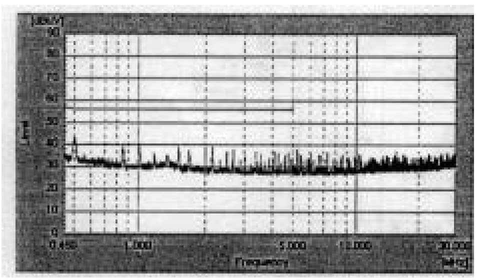


(c) CM conduction noise

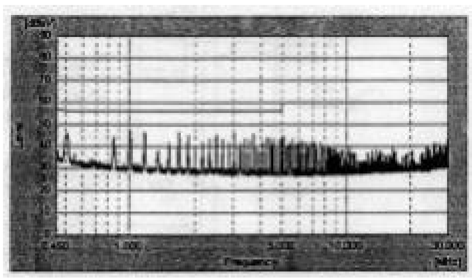
**Fig.4 Conducted noise of SMPS without line filter**



(a) Total conduction noise



(b) DM conduction noise



(c) CM conduction noise

**Fig.5 Conducted noise of SMPS with line filter**